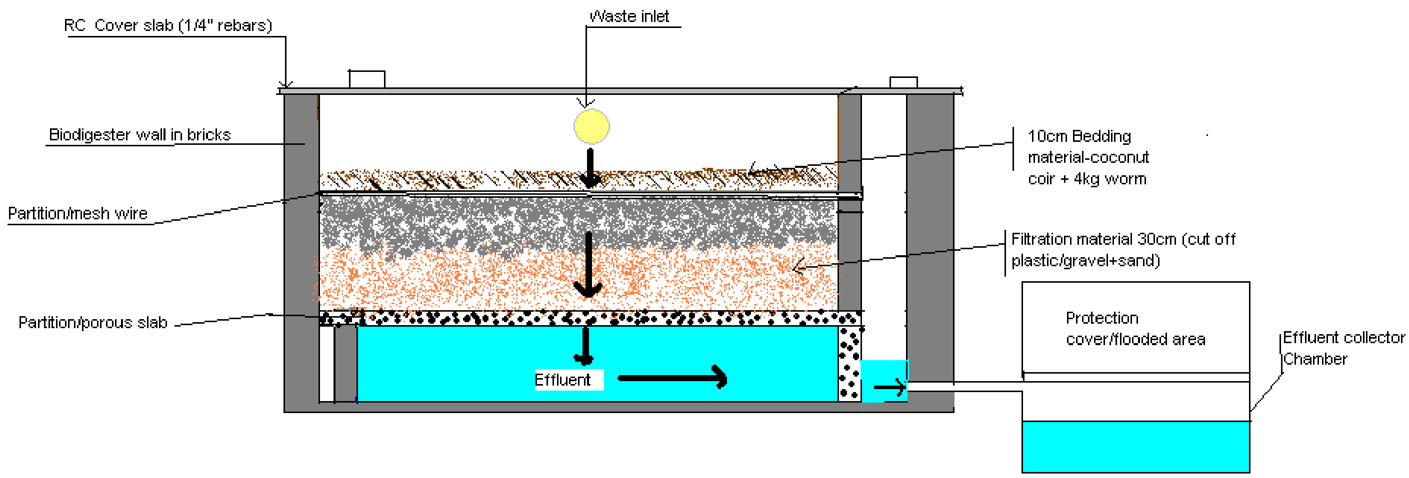
Design, construction and maintenance of a Tiger Worm Toilet

The Tiger Worm Toilet (TWT) is an on-site system that treats human waste using composting worms. The worms digest the faecal matter, which reduces the pathogen load and the frequency of emptying. The system is smaller than a septic tank and the by-product, i.e. vermicompost, is safe and easy to handle.

This Technical Briefing Note describes this new on-site sanitation option. In particular, it looks at the design, the construction, the operation and maintenance, the cost, the monitoring and the performance of a TWT, considering both the technical and socio-cultural perspectives.



The Tiger Worm Toilet as a sustainable sanitation

Existing on-site sanitation options are limited and there are a number of issues with their design. Most people in developing countries rely on pit latrines and septic tanks. Septic tank is unaffordable for most households on low incomes and requires land space making it unsuitable for densely populated areas. Pit-latrine users face problems of smells, flies and visible excreta. Furthermore, a major concern associated with these options is that they need to be emptied, which can be expensive and hazardous.

The Tiger Worm Toilet (TWT) addresses all these concerns. The TWT is an affordable, compact (i.e. less than 0,1 m^3/user [Ref 1]) low-maintenance and safe technology using composting worms to digest faecal waste and turn it into vermicompost. The rate at which solids accumulate is significantly reduced, resulting in a non-pathogenic, dry and odourless product as well as an effluent that is sufficiently treated so that it is safe to infiltrate into the soil [2]. This technology reduces the frequency of emptying and treats the waste, so that handling and disposal are safe. Vermicompost can be used as a soil conditioner.

In 2009, the Bill & Melinda Gates Foundation awarded a grant to the London School of Hygiene & Tropical Medicine to help find innovative solutions to the problem of pit latrine filling [1]. The lead innovation to emerge from this project was the TWT [1]. Laboratory studies were carried out and a prototype was developed and tested at the Centre for Alternative Technology in Wales. Then, TWTs have been trialled in different contexts (i.e. urban, rural and humanitarian camp) through individual projects carried out by Oxfam in Liberia and Ethiopia as well as via a joint consortia with Oxfam, ICCO-Cooperation, Water for People and Primove India; funded by USAID and which targeted trials in India, Myanmar and Uganda.

The Liberia TWT consists of a pour flush latrine connected to a concrete chamber, i.e. the biodigester (figure. 1). The latrine is made of a low volume pour flush toilet with a water seal that

prevents odours and flies back up the pipe. Waste is flushed through into the biodigester and trapped on top of the bedding layer, where the worms live. The worms feed on the waste, breaking down it and converting it into vermicompost. Then, the liquid effluent is filtered through the underlying drainage layer to further remove suspended solids and organic materials [1]. Finally, the effluent is either discharged into a soakaway or collected in an external sump.

Design of the system

The TWT has been designed to maximise solids digestion and minimize compost build-up. It has been sized for a household of 5-10 people. The design and materials of construction should be adapted to suit the local conditions including the availability and cost of materials, the socio-cultural preferences and physical factors such as the infiltration rate and the height of water table.

What location is suitable?

Four main considerations have to be taken into account concerning the location of a TWT [3]:

- A TWT must be located around 20m from the nearest well or borehole.
- The TWT should not be built in areas that flood higher than the height of the porous slab.
- The TWT should not be built in water stressed areas as water is required throughout the year to flush the system and for worm health. Flushing the toilet requires approximately two litres of water per flush; this is the ideal amount of water per flush to ensure a proper moisture level for the worms.
- The TWT designed so that the effluent is directly infiltrated into the soil should not be installed in areas with a low infiltration rate. Assuming that the daily water load is 100 L for a household of ten people (10 L/person/day), a minimum soil infiltration rate of 100 L/day is required [4; 5]. If

TWTs are installed in areas prone to flooding and with low infiltration rate, the design has to be adapted as explained in the case example below.

Technical specifications

These are the essential components of a TWT and their specifications:

TWT's work most efficiently when the worms are moist, hence the pour flush pan, if they dry out too much they will die. Good drainage needs to be assured as over saturation will also kill them.

- **Low volume pour flush pan**. This is the ideal solution and can be purchased from a sanitation supplier as an off-the-shelf part. Normal pour flush pans can be used but straight pipes are not recommended as can let flies enter unless there is a lid and it may mean more water goes into the TWT.

  In water scarce areas direct drop can be used with a lid as long as anal cleansing water also goes down the hole giving worms the moisture they require. The Sato pan, Fig 3, is recommended for this purpose.

  Figure 3 Sato pan made by American Standard

- **Superstructure**. The superstructure can be made from any locally available materials. It should be a secure private structure and must include a roof to prevent extra liquid entering the system.
- **Worms**. **The quantity of worms** needed is calculated by estimating the weight of faeces supplied each day to the biodigester and by assuming that 1 kg of worms feed on 1 kg of faeces [5]. On average as one person produces 200 g of faeces a day, a household of 10 people produces around 2 kg of faeces and thus 2 kg of worms are required[5]. It is

however recommended to provide the system with 2.5 kg of worms, allowing for the death of 0.5 kg of worms. Moreover, in Liberia, based on the accumulation rate of fresh faeces, it was noticed that the quantity of produced faeces has been above 200 g per person per day, which has required rather 3 kg of worms. The quantity of fresh faeces not eaten may therefore indicate whether the worm population is adequate or not (for more information please see the section "Monitoring, operation and maintenance").

To date the following **species of worms have been used in TWTs** [10]:

- *Eisenia fetida*, commonly known as redworm, tiger worm, brandling worm, panfish worm, trout worm, red wriggler worm or red Californian earth worm,
- *Eisenia andrei*, i.e. a close relative of the *E. Fetida*,
- *Eudrilus eugeniae*, also known as African Night Crawler.

Other species of composting worms may work in the system such as *Lumbricus rubellus* (also known as true redworms, dung worms or red marsh worms) and *Perionyx excavates* (also known as blues or Indian blues) [10].

Descriptions and photos of *Eisenia fetida*, *Eisenia andrei* and *Eudrilus eugeniae* can be found below to aid in their identification[1].

Eisenia fetida (fig. 3). This species is the most popular vermicomposting worm in Europe and North America. Although it is native to Europe, today it can be found worldwide except in Antarctica. These worms can process a large amount of organic waste, they are fast reproducers and tolerate a wide range of temperature, acidity and moisture conditions. When adult, i.e. sexually mature, their length ranges from 26 to 130 mm and their girth ranges from 2 to 6 mm. They are red in appearance (with no sheen) and when they move they have a striped appearance. They are easy to handle, although if handled roughly they will exude a pungent white/yellow liquid.

Eisenia andrei (fig. 5). These worms are a close relative of the *E. fetida,* but they lack the buff and red stripes of *E. fetida*. It has the same performance characteristics as *E. fetida*.

Eudrilus eugeniae (fig. 6). These worms are native to west Africa but are found in other tropical and subtropical regions. They die at temperatures below 10 °C. They are red with a blue iridescent sheen. They are large worms and are between 90 to 185 mm. They have distinctive behavior of tying themselves into knots when disturbed (fig. 7) and additionally they move with a snake type motion.

1 The description and photos have been extracted from the "Worm Care Manual for Bear Valley Ventures" [10].

Figure 4: *Eisenia fetida*, also known as tiger worm

Figure 5: Comparison of *E. fetida* and *E. andrei*.

Figure 6: *Eudrilus eugeniae*.

Figure 6: When disturbed, *Eudrilus eugeniae* ties itself into knots.

The table 1 below shows the environmental conditions required by the species of worms used for the TWTs. Aerobic conditions are also important for the worms but also for other organisms such as aerobic bacteria that play an important role in the process.

Table 1: Environmental conditions for the worms (source: C.Furlong's presentation + [10]).

Parameter	**Range**	**Optimal**
Temperature (°C)	5-35	20-25
Humidity (%)	50-96	60-80
Feed rate (Kg feed/Kg worms)	0.8-2.0	1.0
Food layer depth (cm)	-	10-15

Worm loading (kg/m^2)	0.8-2.0	2.0

Depending on whether the country has a history of vermicomposting and worm farming, **the worms can be sourced by farming them and/or by importing them**. For example,

- In Ethiopia, *Eisenia fetida* worms have been sourced by both growing up them locally and importing them from South Africa [4, 11].
- In Uganda, both *Eudrilus eugeniae* and *Eisenia andrei* have been used. *Eudrilus eugeniae* worms have been found and harvested in the country while *Eisenia andrei* worms have been ordered from South Africa [11].
- In India and Myanmar, *Eisenia andrei* worms have been used and farmed in-country [11].
- In Liberia, *Eudrilus eugeniae* worms have been used and harvested in-country [5].

A diagram of the lifecycle of the tiger worm (*Eisenia fetida*) can be found below (fig. 7). **These are the key steps to harvest worms** [10]:

- Collect (fig. 8) and/or sexually mature worms. Worms are both male and female. A worm is sexually mature when there is a swollen region between its head and its tail. This region is called the clitellum.
- Set up a vermicomposting system, i.e. a container filled with moistened bedding. As worms breathe air, the container should be designed to ensure a proper aeration (e.g. by adding holes to the sides). It should also be covered to prevent flies and other organisms entering the system. The bedding layer provides a layer that worms live in and holds moisture. This layer is normally organic and is some form of cellulose. It should also be composed of materials allowing air exchange through the depth of the container. Suitable bedding materials are shredded newspaper or computer paper, partially decomposed leaves, animal manures, coconut fibre, wood chips, soil. It is very important to moisten the dry bedding materials before putting them in the container. The container should be about three-quarters full of moistened bedding.
- Spread the worms across the bedding layer.
- Feed the worms by burying the food in the bedding layer to avoid flies and smell problems. Worms eat food waste such as fruit and vegetable peels, pulverized eggshells, tea bags and coffee grounds. It is recommended not to compost meat, bones and dairy products because of problems with smells, flies, and rodents. Moreover, high levels of citrus will kill worms. The correct ratio of worms to food waste should be: for 2 kg of worms, add 0.5 kg of feed per day or 3.5 kg of feed per week.
- Keep the vermicomposting system in the conditions that the worms thrive in (table 1). The ideal temperature for most vermicomposting worms is 25°C. However, they tolerate a range of temperatures from 10°C to 30°C. If the temperature is above 30°C, add of water to the bedding layer and cover it with a wetted shade cloth. If below 10°C, add a 10 cm layer of dry straw for insulation and cover it with a shade cloth. The moisture levels in the bed should be between moist and wet. These conditions are generally kept by adding 0.5 L of water to the bed weekly. If the bed is too moist, it may go anaerobic, leading to bad smells. In that case, do not add any water to the bed for one day and then recheck the conditions the following day.
  If there are a number of dead worms outside the bed (i.e. 20 or more), this could be an indication that the conditions in the bed are not correct, e.g. a section of the bed had gone anaerobic or there is not enough food for the worms. The baby worms and the cocoons are also a good indicator of the health of the vermicomposting system: if there are lots of cocoons this means that the worms are happy.
- Cocoons take approximately six weeks to hatch and reach maturity [12].

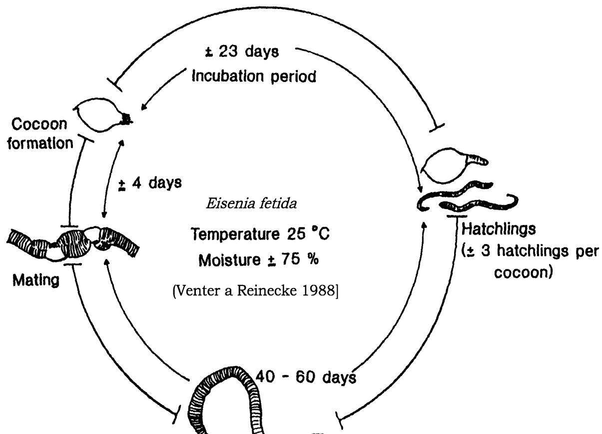


Figure 8: Lifecycle of the tiger worm, *Eisenia fetida*. The duration of the lifecycle depends on the species [10].

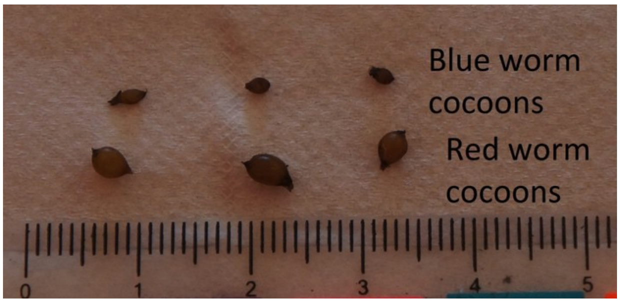


Figure 9: Cocoons of blue and red worms. The colour of the cocoons starts out light and then gets darker the closer they are to hatching [10].

Two studies were carried out to assess the capacity of India and South Africa to supply and export composting worms. It was found that the South Africa worm industry has the capacity to supply over 3,000 kg of live worms per month and to increase their production to over 11,000 kg per month if there is a demand [12]. The current monthly supply of worms has the potential to process the faecal sludge from an average sized humanitarian camp (i.e. a camp housing 11,400 people) [12]. The commercial production and the exportation of worm cocoons are less developed [12]. In India, the companies that responded to the survey have together the capacity to supply over 70,000 kg of worms per month [13]. They have the potential to increase their production up to 150,000 kg or more depending on demand [13]. Some companies stated they could supply cocoons if there is a demand. However, the cocoon production and prices are less established [13].

To import worms in a country, the laws in force in the country have to be complied with. A phyto-sanitary certificate is normally required for importation of live organisms [7]. Once received, if the worms cannot be placed directly in TWTs, they should be stored in a vermicomposting system similar to the system used for harvesting worms (please see above).

- **Biodigester.** The optimal size of a biodigester for 10 people measures 1.2 m high, 1 m long and 1 m wide (internal dimensions). This size has been calculated taking into account the optimal worm loading, i.e. 2 kg/m^2, as well as the depths of the different layers and structures included in the biodigester (e.g. the bedding and drainage layers, the porous slab, the effluent transit chamber) (fig. 1). The biodigester can be offset (fig. 10) or directly below the toilet, which makes it more appropriate for high-density urban environments [4]. If the biodigester is off set, it can be built above or below ground depending on environmental conditions (e.g. flooding) and user preference [3]. It is however important that the inlet pipe connecting the biodigester to the pour flush pan is angled at 15 degrees [4].
- **Bedding layer**. The bedding should be approximately 30 cm below the inlet and 10 cm deep [3]. The bedding should be made of materials which are not easily compressed to ensure an aerobic environment. Materials which are known to function well as bedding are coir (coconut compost), vermicompost, woodchips and/or a combination of them.
- **Drainage layer**. This layer supports the bedding and should be around 30 cm deep [3]. It acts as a filter for the effluent by further removing suspended solids and organic materials [1]. Moreover, this layer is composed of air spaces that can get filled with the effluent if the infiltration rate is insufficient, which proctects the bedding layer against flooding. This layer should consist of a graduated superposition of materials of different size, with the finest material at the top (e.g. sand) and the coarse one at the bottom (e.g. aggregate) (for examples please see the construction techniques below).
- **Effluent collector**. According to the physical constraints (e.g. high water table, areas prone to flooding and with low infiltration rate), effluent can be either discharged into the surrounding ground through a soak away or collected in an external sump. The soak away must be sized according to the expected influent quantity versus infiltration rate over a period of time. The external sump can be an emptied drum of 200 L as used in Liberia [5]. The slope of the pipe between the biodigester and the effluent collector should be minimum 2% [5]. In Liberia, the effluent liquid has been used as fertiliser for kitchen garden crops. Unless precautions are taken this is potentially hazardous as the effluent does contain faecal matter.

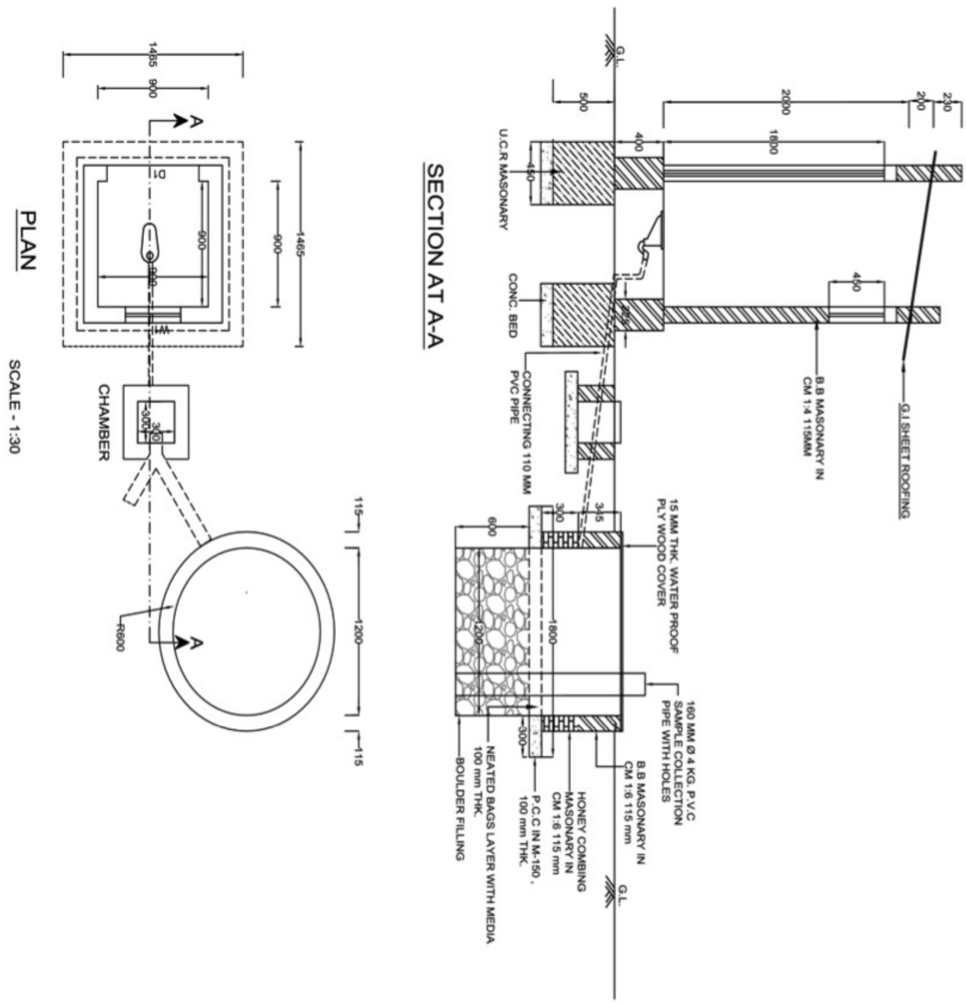


Figure 10: Design of a TWT built in India (note: all dimensions are in mm) [11]. The liquid is discharged into the soil through a soak away installed directly underneath the biodigester. A chamber was installed to sample the influent as part of field trials of prototypes [7]. This sample chamber is not longer required in the current TWT systems [7]. The difference between the Indian design and the Liberia design is that the Indian model does not have the porous concrete slab which makes construction easier and cheaper.

From the experience in Ethiopia, it takes one day to organise the orders for the TWT system and two days to arrange the materials and transport. The construction of a TWT system requires the labour of three workers (one skilled and two unskilled) for five days [4]. In Uganda, the toilet took various amounts of time to build, from two man-days to 15 man-days, which was due to the superstructure being prototyped [8]. In India, Myanmar and Ethiopia, the building process took approximately between eight to ten man-days [4; 8].

First of all, it is important to landscape the area around the TWT system to direct the rainwater off of it [4].

Construction of the biodigester

Above-ground biodigester – case example from Liberia [5; 9]

Build a 7 cm concrete **foundation** with the surface of 1.52m*1.32m (fig. 13).

Figure 13: Building of a concrete foundation for an above-ground biodigester, Liberia.

The internal dimensions of the biodigester should be 1.2 m high, 1 m long and 1 m wide. Plaster the outsidee and internal walls with mortar.

Figure 14: Construction of an above-ground biodigester.

Construct **the walls of the biodigester** by using 6" (15.24 cm) concrete blocks and mortar (fig. 14).

Construct **the lid** of the biodigester by pouring a slab of reinforced concrete (fig. 15). The dimensions of the lid should fit with the surface of the biodigester (i.e. 1.52*1.32m). The recommended thickness is 0.05m.

Figure 15: Pouring of a cover slab, Liberia.

Installation of the inner parts of the biodigester – case examples from Ethiopia and Liberia

Firstly, set up **the drainage layer**. For example, in Ethiopia and Liberia, the drainage layer consists respectively of a superposition of 30 cm of 4 cm aggregate and 10 cm of sand [4] and of a superposition of 15 cm of sand, 5 cm of charcoal, and 10 cm of gravel (fig. 17 & 18) [5]. Alternative materials can be used provided they can be climbed by worms (e.g. plastic bottles or pipes) [5].

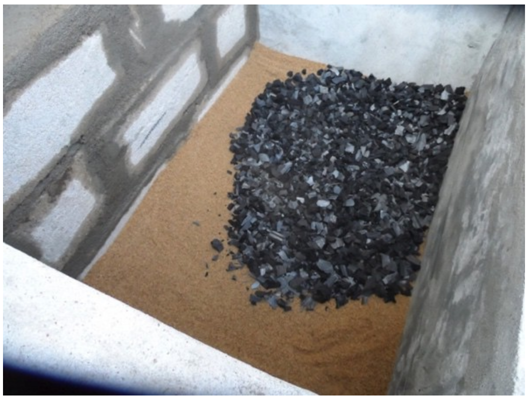


Figure 16: Set-up of the bottom layer and the intermediate layer of the drainage layer, i.e. 15 cm of sand and 5 cm of charcoal, Liberia.

Figure 17: Set-up of the upper layer of the drainage layer, i.e. 10 cm of gravel, Liberia.

In Liberia, **a reinforced porous slab** has been installed below the drainage layer to further filter the effluent (fig. 19) [5]. The slab has been precast, using 1:3 cement mix and ¼" gravel. The surface of the slab should be a bit smaller than the inner surface of the biodigester, i.e. 1.1m*0.9m. The thickness of the slab should be minimum 5 cm, which is the structural minimum for the load [9]. To increase the porosity of the slab, it is recommended to insert wires into the slab two hours after casting and to leave it until the following day [5]. A proper porosity is crucial to ensure the flow of the effluent liquid.

Figure 19: Precast reinforced porous slab, Liberia.

Secondly, set up a 10 cm **bedding layer** by using coir, vermicompost, woodchips and/or a combination of them.

In Liberia, **an additional intermediate layer** has been installed between the drainage layer and the bedding layer as well. This layer consists of a metal mesh or onion bags (fig. 20). The goal is to help users empty the system by leaving that layer out and thus disposing the vermicompost easily.

Figure 20: Positioning of onion bags above the drainage layer, Liberia.

Finally, wet the bedding layer by pour 20 litres of water slowly across the top of the tank and add the worms by distributing them across the surface (fig. 21) [4]. Then, close the tank lid and seal the joint between the lid and the tank.

Figure 21: Provision of worms to the biodigester.

Construction of the effluent collector – case example from Liberia

In Liberia the effluent collector has been constructed using a plastic drum with a lid and a 2" PVC pipe [5] (fig. 22). The slope of the pipe between the biodigester and the effluent collector should be minimum 2% [5]. A hermetic lid is needed to ensure that external water does not enter in the system. Moreover, in areas prone to flooding, it is recommended to raise protection walls around the effluent collector to protect it against flooding.

Figure 22: An effluent collector constructed with a plastic drum in Liberia. Protection walls have been raised around the drum to protect it against flooding.

Installation of the pour flush pan and plumbing – case examples from Ethiopia

These are the main steps in the installation of the pour flush pan and plumbing as implemented in Ethiopia [4]:

- Backfill partially the foundation of the superstructure with the soil from the excavation.
- Position the toilet pan at the level of the slab which it will be set into.
- Install a 70-mm-diameter and one-meter long pipe connecting the biodigester to the pan (in Liberia, a 4-inch-diameter PVC pipe has been used)
- Further backfill the foundation with soil up to 20 cm below the level of the slab. The rest of the space should be backfilled with sand.
- Lift the slab and connect the pan to the pipe. The angle of the pipe should be 15 degrees.
- Once in the correct position, mortar the pan in place and seal the side of the slab.

Once the plumbing system is installed, screw up several large handful of toilet paper, wet them and make them into balls. Then flush one down the toilet with two litres of water, repeat this and note where the ball lands. Ideally it should land in the middle of the tank, trim the inlet pipe until this occurs.

Monitoring, operation and maintenance

Before handing over the TWT to the household, a training on the operation and maintenance of the system should be provided. In Ethiopia and Liberia, a helpline has also been assigned so that households can report any faults or problems with the system [4; 5]. Additionally, in Ethiopia, a pictorial guide on the terms of use has been attached to the back of the door of the toilet [4].

The inside of the biodigester should be inspected every three months [5]. In particular, three aspects of the system should be checked, i.e. the transformation of faeces into vermicompost as well as the health and the number of the worms [5]. From field trials in Myanmar, Uganda and India, it was found that the TWT systems can cope with up to 70% faecal coverage: above this it is likely that the systems become anaerobic, which is linked to bad smells [8] It should be noted that it takes approximately six weeks for the worms to acclimatise to a new food source [14].

If there are any dysfunctions (i.e. an accumulation of fresh faeces, no worms seen for a prolonged period of time), a technician should be contacted. The table 3 (see next page) details some dysfunctions and how a technician should troubleshoot them.

The accumulated vermicompost should be removed as soon as the biodigester is full. It is expected to be removed every 3-5 years on average and is estimated to be 50 kg per toilet [3; 4; 15]. The vermicompost can be disposed by mixing it with soil in which a tree can then be planted [4; 5]. A new bedding layer should be set up and worms should be added to the system if some have been removed with the vermicompost (usually the worms move to the drainage layer when the bedding layer is being manipulated) [5

Table 2: Instructions for the operation and maintenance of a TWT system [5; 3; 10; 16].

Actions	Instructions
Cleaning of the inside of the superstructure and the pan	▪ Do not use chemical cleaners. ▪ Use only clean water to wash the bowl. ▪ Use fresher spray if needed.
Control of insects (e.g. flies, ants) and odour	▪ Use insecticide to fumigate the area surrounding the biodigester (outside). ▪ Spray the toilet with an insecticide and/or an odour eliminating product as long as needed. Flies can also be controlled by using fly papers. To get rids of ants, apply the following substances around the toilet: cayenne pepper, eucalyptus oil, lemon juice, lemon-scented oil, mentholated rub, talcum powder tanglefoot or any sticky substance. The ants will not cross these substances. ▪ Always keep the surrounding area of the biodigester clean and clear. ▪ Around two litres of water per flush are required to keep the system aerobic and to maintain the water seal, which stops odours and flies entering the superstructure. ▪ Ensure that the lid is on correctly.
Substances and materials that can and cannot be put down the toilet	▪ Use around two litres of water per flush. ▪ Collect menstrual management materials and dispose of them separately. ▪ Do not flush anything non-biodegradable or chemicals, e.g. cigarette butts, diapers, condoms, household chemicals, bottles, plastics. ▪ Always use soft tissue or water for posterior cleaning (no plastic and hard paper such as cement sacking).

Table 3: Examples of dysfunctions and troubleshootings [5; 16; 17; 18].

Dysfunctions	Troubleshootings
Lots of flies	If flies are in the superstructure, the water seal may not be working properly. Inspect the seal. Ask family to flush with water to create a water seal. If flies come out the tank, check that the lid and the manhole cover close properly.
No worms seen for a prolonged period of time, i.e. one month or they are climbing the walls then	It means that the system may be flooded or anaerobic, which is linked to bad smells. For further information, please see below.
Bad smells (ammonia)	Bad smells may result from anaerobic conditions in the biodigester due to insufficient drainage. While, urine causing the bad smells needs to be washed through the system too much water will turn it anaerobic and the worms will die or try and escape.
Water standing in the biodigester	Ask the users how many people are now using the toilet verses the design figure. Then, ask the users whether they have been washing in the superstructure. If they have, advise against this and revisit after a day to see whether the effluent level has dropped. If the level has not gone down, do a permeation test to check whether the soil is saturated around the system. If you find that it is saturated close the toilet and monitor the soil around the tank. Water standing in the biodigester can also be due to a low ability of the drainage layer to drain the liquid. If so, remove the waste and replace the drainage layer. If there is a reinforced porous slab, ensure that the porosity is sufficient enough to drain the effluent liquid.
Accumulation of fresh faeces	Firstly, as the TWT has been designed for ten people, make sure that the correct number of people is using the toilet. Then, if required, add worms.

How effective is the TWT?

The TWT has been designed to maximise solids digestion and minimize compost build-up [3]. From laboratory testing at 1/10th scale, it was found that [19]:

1. Faecal solids were reduced by up to 100%.

2. Chemical oxygen demand (COD) was reduced in the effluent by up to 87% compared with the influent.

3. Thermotolerant coliforms (TTC) (pathogen indicator) were reduced in the effluent by 99% compared with the influent.

Moreover, there was minimal accumulation of vermicompost in the system after one year of operation, i.e. about 15% by weight of the faecal solids [15]. A full-size prototype has been successfully run in the United Kingdom; this mirrors the pilot data in performance [3].

Evidence from the field showed that the TWT systems can cope with up to 70% faecal coverage: above this it is likely that the systems become anaerobic [8]. In India, the data demonstrated a rapid and virtually complete digestion of faecal solids [20] In four of the toilets, worms were processing each day the amount of waste entering the biodigester [20]. This increased processing of the waste was thought to be linked to the worms and the higher temperatures in the field compared to the laboratory and the prototype [20]. The worms used were acclimatised to these temperature conditions as there were sourced from a local worm farmer [20]. In Myanmar and Uganda, some incidents were recorded when cleaning products have been used, which may have affected these TWTs adversely [8].

Cost of the system

Comparison of TWT systems

The construction costs (US$) (without economies of scale) of a TWT (including the labour and the material costs of the superstructure, the pan, the plumbing, the biodigester, the inner parts and the effluent collector; excluding worms) built in Uganda, India, Myanmar, Liberia and Ethiopia [4; 5; 21].

U$	Uganda	India	Myanmar	Liberia	Ethiopia
Cost	309	359	275	439	363*

* Excluding the cost of the pour flush pan.

In Uganda, the TWTs have been set up in Mukono Town, a peri-urban area. They are made of a ceramic pour flush toilet with a water seal, an underground biodigester and an offset superstructure built with interlocking concrete blocks (fig. 23). In Uganda, 2 kg of locally sourced African Night Crawlers cost US$20 [22]. The cost of a TWT including two kg of worms is therefore US$329 which is lower than the cost of a VIP latrine, i.e. one of the most common sanitation systems used in Mukono Town [21].

Figure 23: A TWT built in Uganda [11].

In India, TWTs have been built in a rural area. They consist of a toilet pan with a water seal as well as an offset, underground and circular biodigester (fig. 24). The cost of a TWT is US$393 including two kg of worms at US$17 per kg [22]. This cost is lower than the cost of a twin pit latrine which is the most popular sanitation system in rural India [22].

Figure 24: Addition of the worms to the biodigester, India (left). A toilet with its owner, India (right) [23].

In Myanmar, the cost of a TWT has been estimated at US$275 (fig. 25), which is lower than the cost of the pour flush dual pit latrines built in the Maina internally displaced persons camp. However, this cost does not include the expensive cost of worms, i.e. US$210 per kg, caused by a government monopoly [22]. This cost could be significantly reduced if worms businesses are developed alongside [22].

Figure 25: TWTs installed in the Maina IDPs camp in Myanmar [24].

In Liberia, the biodigester has been connected to either a normal volume squat system or pedestal system which was housed inside the home and operated by a pour flush system [6]. This siting was to minimise the cost of the system as an external superstructure adds significantly to cost. However, the toilet slab has to be raised to achieve the proper slope between the pan and the biodigester, which involved high costs (fig. 26) [9]. This also limited the amount of people using the toilet due to privacy issues. The current cost of the TWT is approximately US$439, excluding the worms. The worms were collected by community members who were paid US$7 per kg of worms [6]. The present design is heavily reliant on concrete which accounts for about 33% of the cost of materials [6]. Different materials and their cost should be explored, e.g. clay or mud bricks for the tank, bamboo for reinforcement, wood for the lid of the tank [6]. Moreover, the cost of the sanitary hardware is relatively high due to a lack of competition within Monrovia [6]. The development of a "SaniMart", the importation of low cost low volume pour flush systems or the local manufacture of such systems from fibreglass should be explored [6].

Figure 26: Normal volume squat system (left) and pedestal system (right) used in Liberia (source: ppt urban sanitation in Monrovia).

In Ethiopia, the overall cost of the system excluding the pour flush pan and the worms is approximately US$ 363. In order to reduce the cost of the system, the biodigester wall has been incorporated into the superstructure wall (fig 27). The superstructure accounts for approximately 70% of the overall cost of materials; this could be reduced by using more local materials such as mud bricks, wooden slab and frame as well as a curtain instead of a door [4].

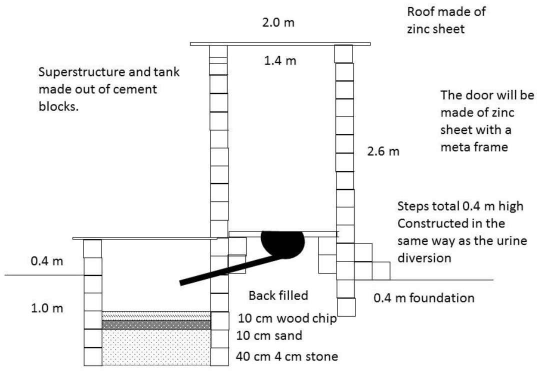


Figure 27: Design of a TWT installed in Ethiopia. The cost of the system was reduced by incorporating the biodigester wall into the superstructure wall [4].

In conclusion, through effective design, careful choice of materials and large scale manufacture the TWT can be an affordable system compared with current options [3]. An eventual target purchase price for the TWT of around US$150 has been set [3].